MULTIMEDIA UNIVERSITY

STUDENT ID NO

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# MULTIMEDIA UNIVERSITY

# FINAL EXAMINATION

**TRIMESTER 2, 2015/2016**

## TPR2251 – PATTERN RECOGNITION

( All sections / Groups )

3 March 2016
2.30 pm – 4.30 pm
( 2 Hours )

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**INSTRUCTIONS TO STUDENTS**

1. This question paper consists of 6 pages with 6 questions only.
2. Attempt **FIVE** out of **SIX** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please print all your answers in the answer booklet provided.

## QUESTION 1

(a) Describe the following basic modules in designing a pattern recognition system:

(i) Feature extraction
(ii) Classification

[2 marks]

(b) Describe the input and output of the following pattern recognition applications:

(i) Speaker recognition
(ii) Optical character recognition
(iii) Remote sensing

[3 marks]

(c) It is known from the past experience in Bukit Katil that the probability of selecting an adult over 65 years old with arthritis is 0.15. If the probability of a doctor correctly diagnosing an adult with arthritis as having the disease is 0.88 and the probability of incorrectly diagnosing an adult without arthritis as having the disease is 0.04. Calculate:

(i) the probability that an adult is diagnosed as having arthritis. [3 marks]

(ii) the probability that an adult diagnosed as having arthritis actually has the disease. [2 marks]

**Continued .....**

## QUESTION 2

(a) Figure 1 shows two class-conditional probability density functions by measuring the length of two types of fish, i.e. *kerapu pisang* (class $\omega_1$) and *tenggiri* (class $\omega_2$). From the past experience of a fisherman, the chance of getting a *kerapu pisang* is 0.60.

(i) If you are given a fish from either class with a length $x$=30cm, which class the fish is more likely belonging to? Explain your answer. [3 marks]

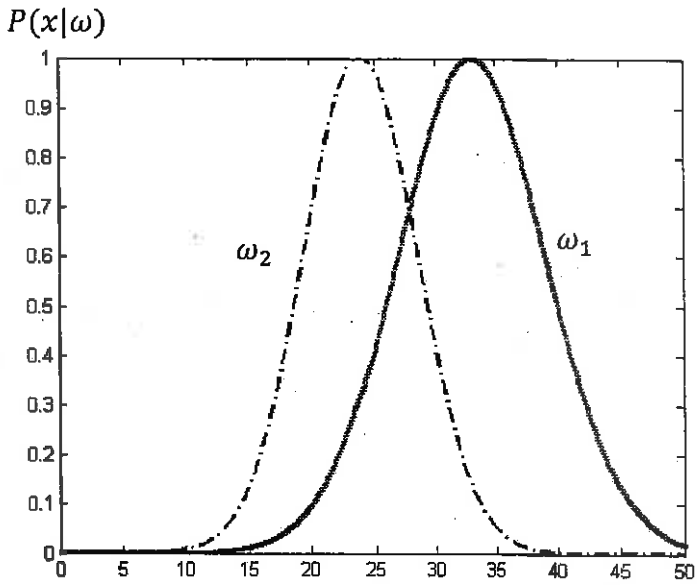



Figure 1 Class-Conditional Probability Density Functions for Two Classes

(ii) Given a loss matrix as follows:

| | $\omega_1$ | $\omega_2$ |
|---|---|---|
| $\alpha_1$ | 0 | 15 |
| $\alpha_2$ | 5 | 0 |

where $\alpha_1$ and $\alpha_2$ denote the action of choosing *kerapu pisang* and *tenggiri*, respectively. What is the expected loss of choosing $\alpha_1$? Assume you have obtained posterior probabilities $P(\omega_1 \mid x)$ and $P(\omega_2 \mid x)$.

[2 marks]

**Continued .....**

(b) The width of a flower petal is selected as the feature to distinguish a flower of type $A$ from a flower of type $B$.

(i) Assume both flowers $A$ and $B$ have equal priors, derive a decision rule to recognise a flower based on the following class conditional densities:

$$P(x \mid A) = \frac{1}{\sqrt{2\pi}} e^{-\frac{(x-1)^2}{2}}, \quad P(x \mid B) = \frac{1}{\sqrt{2\pi}} e^{-\frac{(x-9)^2}{2}}$$

[4 marks]

(ii) By referring to the solution from (i), how would the decision rule be affected if the prior of flower $B$ is greater than the prior of flower $A$? [1 mark]

## QUESTION 3

(a) A two-dimensional Gaussian probability density function $N(m, S)$ has a mean $m = [1,1]^T$ and a covariance matrix $S = \begin{bmatrix} \sigma_1^2 & \sigma_{12} \\ \sigma_{12} & \sigma_2^2 \end{bmatrix}$. Draw/sketch the graphs for the Gaussian density function for the following two cases. For each case, explain your answer.

(i) $\sigma_1^2 = \sigma_2^2 = 1, \ \sigma_{12} = 0$ [2 marks]

(ii) $\sigma_1^2 = 0.1, \ \sigma_2^2 = 1, \ \sigma_{12} = 0$ [2 marks]

(b) A 2-class 3D classification problem is defined by the following Gaussian Likehoods:

$$\mu 1 = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}; \quad \mu_2 = \begin{pmatrix} 2 \\ 2 \\ 2 \end{pmatrix}; \quad \Sigma_1 = \Sigma_2 = \begin{pmatrix} \frac{1}{2} & 0 & 0 \\ 0 & \frac{1}{2} & 0 \\ 0 & 0 & \frac{1}{2} \end{pmatrix}; \quad P(w_2) = 4P(w_1)$$

(i) What are the two discriminant functions? [2 marks]

(ii) Based on the outcomes from (i), identify the decision rule. [3 marks]

(iii) Determine the class of a test sample if its result from the discriminant function from (ii) is 5.33. [1 mark]

**Continued .....**

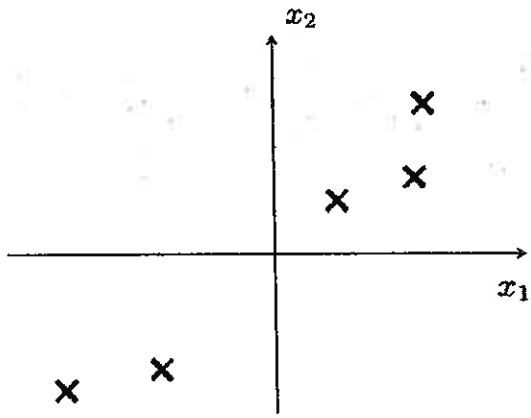
## QUESTION 4

(a) Dimension reduction is a popular approach in pattern recognition and machine learning.

(i) List TWO advantages of using dimension reduction techniques. [2 marks]

(ii) Give an application which benefits from dimension reduction and explain how it works. [2 marks]

(b) Consider the following 2-dimensional dataset. Explain how principal component analysis (PCA) can be used to reduce the dataset to 1-dimensional. [2 marks]




(c) Consider the following credibility data used by a bank to decide whether to approve a credit card application.

| Age | Credit Score | Decision |
|---|---|---|
| 25 | 40 | N |
| 38 | 30 | N |
| 35 | 30 | N |
| 30 | 85 | Y |
| 40 | 45 | Y |
| 42 | 50 | Y |
| 45 | 55 | Y |

(i) Given an unknown applicant whose age is 30 and having a credit score of 65. Use nearest neighbor with $k = 1$ to predict whether the application will be approved. Euclidean distance may be used in the calculation. [2 marks]

(ii) Use $k = 3$ to predict whether the application will be approved. What do you observe from the answers in (i) and (ii)? [2 marks]

**Continued .....**

## QUESTION 5

(a) Explain the *k*-means clustering algorithm. You can illustrate the procedure using a pseudo-code. [3 marks]

(b) A health and nutrition magazine tested eight brands of ginkgo biloba dietary supplement. The test results are shown in the table below.

| Brand | Flavone Glycosides (%) | Terpene Lactones (%) |
|---|---|---|
| A | 24 | 6 |
| B | 33 | 10 |
| C | 15 | 8 |
| D | 42 | 16 |
| E | 50 | 35 |
| F | 28 | 12 |
| G | 56 | 25 |
| H | 46 | 20 |

The magazine would like to categorize these brands into homogeneous and distinct groups. Dendogram can be used as an analysis tool in this scenario.

(i) Explain single linkage, complete linkage, and average linkage grouping criterion. [3 marks]

(ii) Use complete linkage to construct a dendogram for the dataset. [3 marks]

(iii) How would you advice the company based on the clustering result? [1 mark]

**Continued .....**

## QUESTION 6

(a) What is a training set and how is it used to train a neural networks? [3 marks]

(b) Consider a single-layer feedforward neural network containing only a single neuron (unit). The node has three inputs $x = (x_1, x_2, x_3)$ that receive binary signals (0 or 1). An activation function $\varphi(v) = \begin{cases} 1, & v \geq 0 \\ 0, & otherwise \end{cases}$ is applied to produce the output, $y$.

(i) Sketch the network based on the information provided. [2 marks]

(ii) How many different input patterns can the neuron receive? [1 mark]

(iii) Suppose the weights for the corresponding inputs are given by $w_1 = -4$, $w_2 = 1$, and $w_3 = 2$. Calculate the output value $y$ for the following input patterns:

| Pattern | $P_1$ | $P_2$ | $P_3$ |
|---|---|---|---|
| $x_1$ | 1 | 1 | 0 |
| $x_2$ | 0 | 1 | 1 |
| $x_3$ | 1 | 0 | 1 |

[3 marks]

(iv) How will the output $y$ be affected if the threshold value for $\varphi$ is changed to 2? [1 mark]

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